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Digital Optimization in Architecture's Master's Programme of Selected Private Universities in Lagos and Ogun State, Nigeria

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Abstract:- At the turn of the 21st century, the advent of advanced software from conceptual development of 3D simulation and analytic tools have been developed to aid the development of various architectural presentation techniques and obtain digital optimization. Data was collected from students currently in MSc 1 and 2, using a structured questionnaire and analyzed by using descriptive statistics shows that more men use CAD than the women. A high percentage of MSc students are youths. Most MSc students make use of their computers most times when they are opportune, and those who do this are more likely to keep improving and adapting to various CAD skills and are able to troubleshoot and come up with solutions to problems they would face in those software. Timing for the completion of a CAD design is dependent on skills, the availability of appropriate software/hardware and constant power. This shows that, power supply is a key factor to consider. The information from the questionnaire showed that MSc students who are single have more time and are more focused to practice their skills with various CAD software of which those used in this study are Sketchup, Revit, AutoCAd, ArchiCAD, AutoCAD Civil 3D, Rhino 3D, Vectorworks Architect, 3D Studio Max, Lumion, V-ray, CorelCAD, Corel Draw, Catia, Briscard BIM, MicroStation, Credeo, Twinmotion, Unreal Engine, All Plan, Emscape, Adobe Premiere Pro, and Blender. The impact of these tools on their architectural development were measured based on their projects presented in school. The impact enables understanding of the implication of introducing such software to the school curriculum and creates room for more advancement in this research such as 3D printing or VR (virtual reality), which represents the future of architectural visualization.

Keywords:- *Digital Optimization, Architectural Pedagogy, Simulation, Virtual Reality, Visualization.*

I. INTRODUCTION

A. Background of Study

In recent times, architecture has developed from the famous "manual" drafting method to the now more commonly used CAD (Computer-Aided Design) in Nigeria, particularly in Ogun and Lagos States. The emergence of CAD has greatly innovated and increased the efficiency of delivering projects on time and being able to do more in terms of building design and simulation. In the last few years before the 2000s, manual drafting was a thing of great importance because, it allowed creativity to flourish in the mind of architects at that time, where they would spend more time conceptualizing design solutions for the built environment with the aid of paper and pen "ONLY".

Most concerning at that time was the fact that an error made on paper either while drafting the final drawings or when the client requested a change in the design, resulted in particular sheets being discarded to meet the client's request – on a new sheet – causing fatigue and stress which slowed down the architect's ability to finish up final design drawings within the time limit that he/she was given.

B. The Advent of CAD

CAD is an acronym for **Computer-Aided Design**, simply the digital tools that assists a user (in this instance Architectural Master's Students) in achieving more difficult tasks that would be more complex to attain through a manual means. This study is focused on the digital innovations that CAD has brought into architecture, and the advantages and opportunities that are yet to be tapped into so that we can see how CAD can help ease the study of architecture and in return reduce the burden on Master's students in selected private universities in Ogun and Lagos States (Ponce, 2020).

C. Research Aim & Objectives

Aim

The study aims to evaluate the role of digital optimization in the architectural profession and determine if Master's level students use various CAD software in their various architectural projects and their level of usage or skills in such softwares.

Objectives

1) Identify presentation categorization knowledge base.
2) Examine the usage level of various students in Master's level.

1) Identify presentation categorization knowledge base.

If we are to successfully make known to architects what CAD software are, first we will need to identify those MSc students that are well-grounded in the use of various CAD

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software, those who are not too conversant with them, and also those who do not use CAD at all. We would be examining their design process from the sketch phase, **development Phase, 3D-visualization phase**, **rendering phase, post production phase all the way to the physical modelling phase.**

2) **Examine the usage level of various students in master's level.**

Data on the preference in use of the various CAD will be collected. MSc. students of Ogun and Lagos States will be the point of focus in carrying out this analysis with more emphasis the use of particular CAD software to produce their most successful projects.

3) **Provide evidence that CAD software deliver projects faster or within a specified time.**

When all data on CAD software have been analyzed, there will be the need to evaluate such data to arrive at a final option that shows this method of architectural drafting is the best in terms of delivery, speed, and accuracy.

Some of the research questions were: What are the skills need to be able to use CAD software? How to make it available to both present and future architects. What are the benefits of using these CAD software? How to determine when to use these software.

For architects to efficiently use CAD software, they will need to acquire some basic knowledge of any CAD software. Most CAD software use most of the same commands with little differences in navigation, for example, the zoom command which is done with your middle mouse button is commonly used in between popular CAD software as it is very user friendly and easy to do, three applications that use this commonly are Sketchup, Autodesk AutoCAD, and Autodesk Revit. They use this function very often to draw out details in floor plans, sections, callouts, etc. Every architect that uses these software must first learn this function as well as a few others in other to get around the software's basic navigation for both 2D drafting and 3D modelling.

There are some times where the CAD software in question is too expensive to acquire, i.e., a full license to use the software either annually or within 2-3 years. There is the need to form a sort of partnership with those companies that develop CAD software so that there can be a certain discount in the prices of those software so that architects can still get a hold of what CAD software they require at an affordable rate to carry out their projects. Bells University could even invest in CAD software development. The most beneficial thing about any CAD software is the fact that one can easily correct any error that was made and save time and energy that would have stressful to experience while using manual means.

Other benefits include the generation of easier methods for designing buildings, the faster rate of finishing a projects complete drawings, better presentation skills and output results that will be more attractive to potential clients, better storage means as regards to smaller compression sizes when files are either uploaded to cloud or storing files in an external hard drive and less time consumption. There is also the benefit of freedom to experiment with more complex forms as this relates well to the master's students when they are trying to generate different conceptual adaptations for their design projects.

An MSc student should know when it is necessary to use CAD, and this is determined by the following factors: time management, the scope of a project, student's ability, finance availability, quality of design, and power availability. The issue of **time management** is always on the mind of an architect, we always try to save time when we are executing projects especially big projects so that we do not delay or exceed the expected completion date of the project. This also boils down to the use of CAD and how an architect can prioritize and manage their time to work with CAD software within the projects' completion date.

The **scope of a project** is also an important factor when trying to decide whether CAD should be used or not on the project, but if the project at hand is too large for manual methods as shown in Figures 3 and 4 below, then it advisable to use CAD so that the stress and inconvenience felt by the architect will be reduced because man is not a machine; one can breakdown quickly when pushed to the limit. When CAD is used for such a project, it will greatly reduce the time that it would take another architect to prepare those architectural drawings with pen and paper. The **student's ability** to use this software also matters because, if they are not examined, they may not be able to express themselves well and their skill level will not be known. If they are examined for their usage skill set or experience in the software they use, then a basis can be established and it will be known to the university and from there, the university can look at ways of teaching those students on how to navigate those software.

Finance availability is one of the major factors that determine how far an architect can go with their CAD work when they decide to engage in it. Digital-capable devices like high-end laptops, desktops, printers, etc., can be expensive to acquire, especially after the lockdown period during which most businesses closed down, and some electronics shops had low sales. This can heavily impact the prizes of digital devices in the sense that the very high-end devices are too expensive making it difficult for architects who are not financially buoyant to abandon the idea of using CAD in their practices. However, it is worth the investment when the benefits in clientele flow is considered.

Printing is a somewhat expensive affair when it comes to preparing architectural drawings for a project, but it is can never be compared with the time spent and price of materials that will be purchased for manual drafting. This is why printing of CAD drawings are preferred mostly nowadays. By comparison, in Lagos State, a drafting pen set of 9 Staedtler Mars would be in a price range of N48,000 to N71,000, but a fully printed out architectural CAD project for A2 black & white is N200 while the coloured is N300 minimum, A1 black & white is N600 and coloured is N800. If we take all these figures and multiply them by let's say by 50 sheets

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printed in colour on A2 paper for a complete set of architectural drawings, we would get a total of N15,000 which is cheaper than the pen set on its own. Therefore, architects in general, should look at the financial impact on them and the client when looking at the project at hand to minimize waste of time and money.

CAD drawings are quite eye-catching which is why most architects prefer to have their drawings printed out, as it brings out the work in a neat, tidy, and visually aesthetically pleasing form, because of the perfect arrangement. Without stating that an architect cannot do all of this manually, one should consider the fact that drawings may become messy and one is not always tidy, careful, and cautious when drafting; serious mistakes might be made which could destroy that sheet in particular well as other sheets.

In Nigeria, particularly Lagos State, and the these private schools, power supply is usually available making it possible for the students to engage in the use of CAD in their complex projects to save both time and reduce cost. The world is entering an era of the internet of things. Thus, to compete fairly, it is expected that upcoming Nigerian architects should know the use and benefits of CAD in their various architectural practices so that design projects can be delivered on time, within the session period. Master's students of Architecture in Lagos and Ogun State universities need to realize the potentials and opportunities that are yet to be uncovered in the use of CAD. Generally speaking, not all MSc students use CAD software to deliver their design projects, but the goal of this study is to justify the reasons why they should consider it so that, it can save time and funds. This study is focused on the current architecture Masters students in Lagos and Ogun State selected private universities in Nigeria, and the types and their applications of various CAD software.

II. LITERATURE REVIEW

A. Brief History of How CAD Started From Colonial Nigeria

In recent times, architecture has developed from the famous "manual" drafting method to the now more commonly used CAD (Computer-Aided Design) in Nigeria. The emergence of CAD has greatly innovated and increased the efficiency of project delivery time as well as the ability to be able to do more in terms of building design and simulation. In the last few years, before the year 2000, manual drafting was a thing of great importance because, it allowed creativity to flourish in the mind of architects at that time, where they would spend more time conceptualizing design solutions for the built environment with the aid of paper and pen "ONLY". CAD started in 1964 - in the early 1960s the first commercially available Computer-Aided Design (CAD) systems began to emerge on the market. The first of these was used by large aerospace, engineering, and information technology companies like Lockheed Martin, General Motors, and IBM; it only came into Nigeria in 1997, where plotters were used to print out architectural designs.

In the current dispensation with miniaturized super computers, the development of innovative designs has increased.

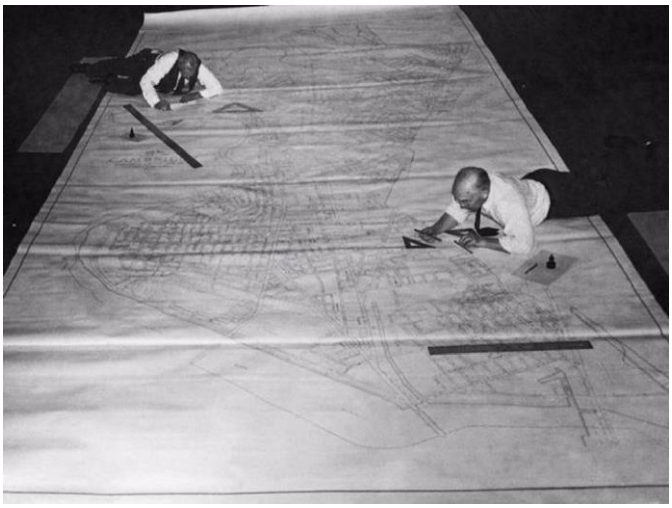

Fig. 1. Architects Drafting-On-Paper with Manual Drafting Tools (source: Google images).

Fig. 2. Architects Drafting-On-Paper with Manual Drafting Tools Lying on Tables (source: Google images).

The most concerning constraint at that time was the fact that if an error was made on paper either while drafting the final drawings or the client requested a change in the design, it would mean that the particular sheet would be discarded and a new sheet would have to be done to correct or meet up the client's request, causing fatigue and unnecessary stress to the architect. Even now, the demands placed on students of architecture is leading to burnout, mental health issues and even thoughts of suicide, according readers participating in a social-media discussion about design education organised by Dezeen (2019).

The design studio is at the core of architectural education at both undergraduate and graduate levels. Many students are admitted based on the criteria set by the Universities Matriculation Examinations (UME), the Universities that offer architecture, the professional bodies

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and the National Universities Commission (NUC). The Nigerian Institute of Architects (NIA) and the Architects Registration council of Nigeria (ARCON) have always supported the education of architecture students, championing the two-tier educational structure that incorporates both the Bachelors and Masters programmes. It has been observed that the rigors of studying architecture requires encouragement and enthusiasm to sustain one's focus and desire to complete the programme. Some students get frustrated at the early stages of the programme due to the pressure to submit assignments on time, and desire to make their exit. Many questions are still being raised about the influence and effect of CAD applications on students' studio skills development and creativity at the undergraduate level in Nigerian universities. The idea of creativity and the importance of enthusiasm in students need to be understood in the context of architectural education. Furthermore the concept of CAD use as a form of motivation and incentive, derived from outcomes of studies is also important (O.A. Dare-Abel, O. Uwakonye, A.P. Opoko, 2016).
(**Dare-Abel et al, 2016)**

B. Ergonomics

The postures adopted by the architects in figures 1 and 2 are considerate, but with the advent of the drawing board, and the tendency to be constantly bent over this board for lengths of time in a bid to meet a client's deadline has posed health challenges to architects. Ergonomics in the life of architects should be placed above that in building architecture; only a healthy architect can produce sound designs. Ergonomics - fitting a job to a person - helps lessen muscle fatigue, increases productivity and reduces the number and severity of work-related musculoskeletal disorders (MSDs).

Fig. 3: Biomedical Diagnostic and Training Centre Exterior Render 1 Done in Lumion 10 by The Researcher

Fig. 4: Biomedical Diagnostic and Training Centre Exterior Render 2 Done in Lumion 10 by The Researcher

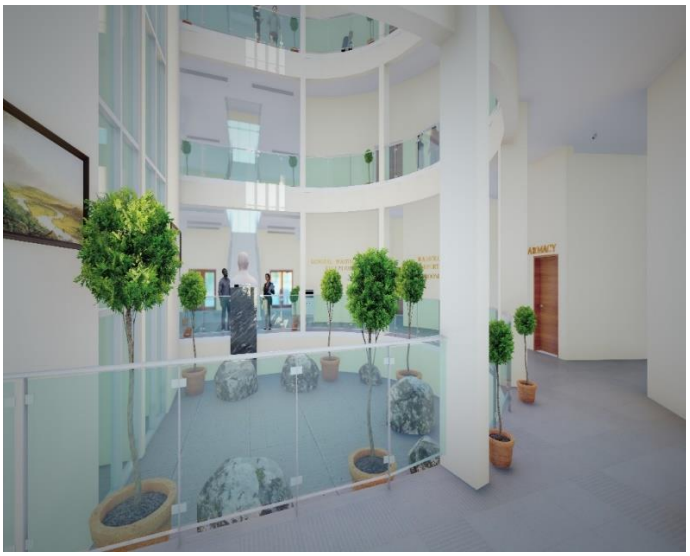

Fig. 5: Biomedical Diagnostic and Training Centre Interior Render 1 Done in Lumion 10 by The Researcher

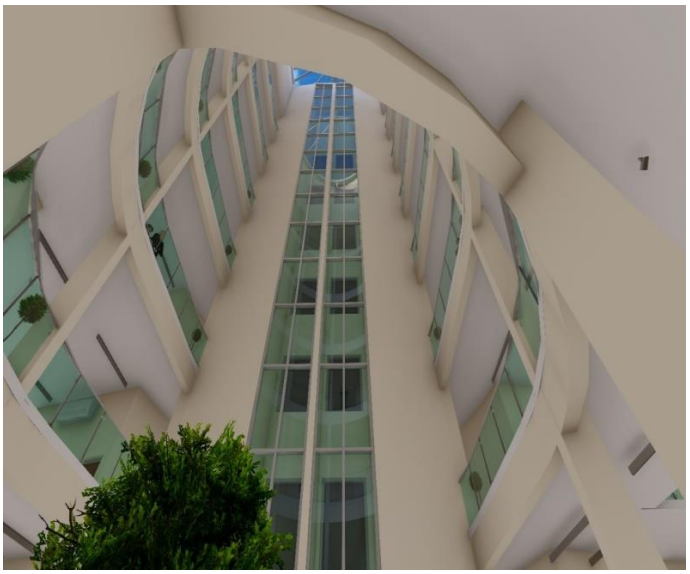

Fig. 6: Biomedical Diagnostic and Training Centre Interior Render 2 of the Atrium Done in Lumion 10 by The Researcher

This **Olusegun Obasanjo Presidential Library (OOPL)** Project, the CAD design of which is shown in figures 3 to 6, is being constructed along M.K.O. Abiola Way, Abeokuta in Ogun State. The designs above were done by the Researcher, using Lumion 10. It was developed in four (4) weeks to aid the architectural presentation to the client, a feat which would have proven impossible with the conventional manual modelling, which usually only shows exterior views.

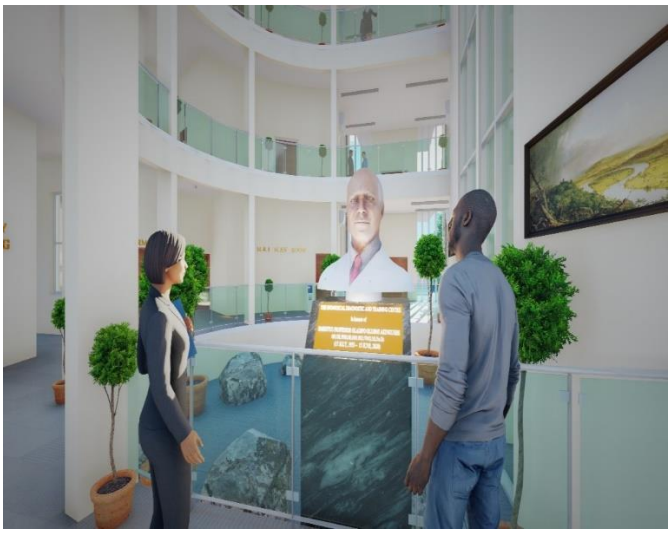

Fig. 7: 3D Bust of the late Emeritus Professor Oladipo Akinkugbe at the Atrium Generated using Avatar SDK and rendered in Lumion 10 by The Researcher

An online web application Web app "AvatarSDK" was used by the Researcher to generate the 3D bust in Fig. 9 of the late Emeritus Professor Oladipo Akinkugbe.

III. METHODOLOGY

This research methodology applied the six (6) presentation categorization knowledge areas for an effective architectural design process. These are:

- **Sketch/Conceptual Phase** - Architects usually sketch first to bring out what they are thinking about into reality employing freehand drawings done on paper, but now architects are finding it easier to do sketches on digital devices (Designingbuildings, 2021).
- **Development Phase** - In the design development phase, the choices in materials, systems, and appliances will largely be finalized in preparation for the construction documents phase (Gilliland, APRIL 2019). **(Gilliland, 2019).**
- **3D-Visualization Phase** - In this phase, architects always have to present their designs to their client and the only way to woo the client is to present the design to them in a manner that is aesthetically pleasing to the eye (Rapina, MARCH 2020). **(Rapina, 2020)**
- **Rendering Phase** - Architectural rendering is the process that involves the creation of photorealistic images and animations in 2D and 3D to show architectural projects in a realistic way.
- **Post Production Phase** - architects may do fantastic renderings of their designs, but they may need to touch it up a bit, make final adjustments to generated images, they may not have the time to repeat the rendering process. This is where post-production is needed to **save time** in other for the architects to add that final effect that will sell their design. It may be done in walkthroughs or still render shots. The point is that time is saved and fewer resources are used up (Digitale, 2018).
- **Physical Modelling Phase** - Real-life models are done to show the client the closest realism of the design without it being built, for instance, if an architect wants to immerse the client in such a way that they are he/she will feel the design and have a sort of fantasy that they can touch and feel what they the client are going to utilize, then the architect would have won the client's heart (Kristiánová Katarína, Viera Joklová, vor Mečiar, NOVEMBER 2018) **(Kristianova et al, 2018).**

The development of digital technologies brought new techniques in architectural modeling and in the presentation of architectural projects – for example, virtual 3D models visualizations or the use of Augmented Reality. However, these new digital technologies have not pushed away the use of conventional three-dimensional physical models to present the architectural projects. Physical 3D models still play an important role in architectural education.

This research was carried out through the administration of an online questionnaire, accessed through Google forms online, and was aimed at the current Master's students, to determine their various **digital** presentation usage skills to see how their studio designs projects are executed and presented. The current BSc students from 100lv-400lv will not be included in the survey because they are not permitted by ARCON (**ARCHITECTS REGISTRATION COUNCIL OF NIGERIA) to use CAD in their studio design projects. The steps that will be used to analyze and obtain results from the survey are as follows: (1)** Developing the questionnaire based on the 6 categorized digital presentation knowledge areas. (2) Examining their various levels of usage of CAD software and the methods of presentation, in 2D or 3D, in terms of architectural drawings e.g. plans, elevations, renderings, etc. (3) Drawing up a conclusion as to which CAD software is used more by the Master's students in their design projects, and giving recommendations on how they can improve on their skills and knowledge of other software by including the use of such software in the syllabus of the universities.

IV. DATA ANALYSIS & PRESENTATION

SECTION A: PRELIMINARY QUESTIONS

Respondents were sourced from Bells University of Technology: 39 (66.1%), Covenant University: 8 (13.6%) and Caleb University: 12 (20.3%), totally 59. Of these, 43 males and 16 females participated, representing 72.9% and 27.1%, respectively. MSc 1 students constitute 71.2% while MSc 2 students are 28.8%. For age distribution, the largest group was the 20-25 years old respondents making up 62.7%, both age groups of 26-30 years and 31-40 years constituted 5.1% each while the 41-55 years group came to 27.1%. Forty (40)

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of the respondents are single while 19 are married, representing 67.8% and 32.2%, respectively. All 59 respondents make use of CAD – of these, 28 used CAD very often, 10 used them every time, 17 used them always while 4 used them not all every time.

Of the 59 respondents, 47.5% use their computers very often while 6.8% do not use their computers every time. For 14 of the respondents it takes two (1) month to finish a design, for 12 (20.3%) 1 week, for 13 (22%) 2 and 3 Weeks each and for 7 (11.9%) 2 Months. About 20% of the respondents finished their design in one week while the 11.9% finished in two months. Overall, data shows that about 88% finish their CAD design in one month.

Constant power supply in the home or studio is available always to only 9 of the respondents, most times to 38 (64.4%) while 12 have no power supply from the national grid.

S/N	SOFTWARE	NUMBER OF MSc STUDENTS BASED ON LEVEL OF USAGE
1	SKETCHUP	G: (11), VG: (10), A: (17), I: (5), E: (2), P: (2), IDK: (14)
2	REVIT	G: (17), VG: (15), A: (12), I: (4), E: (4), P: (3), IDK: (4)
3	AUTOCAD	G: (17), VG: (21), A: (14), I: (1), E: (7), P: (0), IDK: (0)
4	ARCHICAD	G: (8), VG: (5), A: (14), I: (7), E: (1), P: (2), IDK: (27)
5	AUTOCAD CIVIL 3D	G: (11), VG: (0), A: (6), I: (7), E: (0), P: (4), IDK: (35)
6	RHINO 3D	G: (10), VG: (0), A: (8), I: (5), E: (1), P: (2), IDK: (35)
7	VECTORWORKS ARCHITECT	G: (10), VG: (0), A: (5), I: (5), E: (2), P: (3), IDK: (36)
8	3D STUDIO MAX	G: (7), VG: (4), A: (10), I: (4), E: (1), P: (3), IDK: (32)
9	LUMION	G: (6), VG: (9), A: (11), I: (6), E: (5), P: (7), IDK: (18)
10	V-RAY	G: (10), VG: (7), A: (8), I: (6), E: (3), P: (2), IDK: (25)
11	CORELCAD	G: (9), VG: (1), A: (8), I: (3), E: (1), P: (4), IDK: (35)
12	PHOTOSHOP	G: (12), VG: (5), A: (16), I: (6), E: (3), P: (3), IDK: (18)
13	COREL DRAW	G: (13), VG: (9), A: (12), I: (6), E: (2), P: (4), IDK: (15)
14	CATIA	G: (9), VG: (1), A: (4), I: (5), E: (1), P: (3), IDK: (37)
15	BRISCARD BIM	G: (8), VG: (1), A: (6), I: (4), E: (1), P: (3), IDK: (37)
16	MICROSTATION	G: (8), VG: (2), A: (5), I: (4), E: (2), P: (3), IDK: (36)
17	CEDREO	G: (7), VG: (2), A: (5), I: (5), E: (1), P: (3), IDK: (37)
18	TWINMOTION	G: (12), VG: (1), A: (8), I: (3), E: (3), P: (2), IDK: (32)
19	UNREAL ENGINE	G: (6), VG: (3), A: (8), I: (3), E: (3), P: (3), IDK: (35)
20	ALL PLAN	G: (7), VG: (0), A: (8), I: (5), E: (2), P: (3), IDK: (36)
21	ENSCAPE	G: (7), VG: (6), A: (6), I: (5), E: (4), P: (3), IDK: (31)
22	ADOBE PREMIERE PRO	G: (9), VG: (2), A: (10), I: (4), E: (5), P: (3), IDK: (30)
23	BLENDER	G: (9), VG: (3), A: (7), I: (4), E: (2), P: (4), IDK: (33)

Table 1: Tabular illustration to show the level of usage and skills level for the selected soft wares

SECTION B: CAD PRESENTATION USAGE TABLE ANALYSIS

The students were questioned on their use of twenty three (23) CAD software. These are Sketchup, Revit, AutoCAd, ArchiCAD, AutoCAD Civil 3D, Rhino 3D, Vectorworks Architect, 3D Studio Max, Lumion, V-ray, CorelCAD, Corel Draw, Catia, Briscard BIM, MicroStation, Credeo, Twinmotion, Unreal Engine, All Plan, Emscape, Adobe Premiere Pro, and Blender. Of these, the software available to the students are SKETCHUP, REVIT, AUTOCAD, COREL DRAW, CATIA, ARCHICARD, ALL PLAN, 3D STUDIO MAX, VECTORWORKS ARCHITECT, BRISCARD BIM, RHINO 3D, COREL CAD, MICROSTATION and AUTOCAD CIVIL 3D. Most MSc students make use of SKETCHUP, REVIT, AUTOCAD, LUMION, PHOTOSHOP, and COREL DRAW with AUTOCAD being the most used among students with 2nd most used being REVIT, and third most used being SKETCHUP, while CORELDRAW is in 4th place. It was observed that a lot of software are not known to the students for a number of reasons. It is amazing that the MSc students still use CORELDRAW. This may be due its tools which allows the users to quickly edit their design projects with ease, e.g., floor plans, elevations, etc.

SECTION C: CAD PRESENTATION USAGE TABLE ANALYSIS ON SKETCH/CONCEPTUAL PHASE

For assessing the level of usage of CAD software, data analysis shows that most MSc students use SKETCHUP and REVIT for conceptual drawings. This may be due to the fact that, SKETCHUP offers flexibility in terms of the tools that it has. REVIT can also do conceptual designs to get forms, but it can also give them multiple options and they can switch between the two software with ease. Other software in the list are highly unknown to some of the students, some are good while some are professionals at using such software.

SECTION D: CAD PRESENTATION USAGE TABLE ANALYSIS ON DEVELOPMENT PHASE

For sketches development with the various CAD software by the current MSc 1 & 2 students, most MSc students make use of AUTOCAD and REVIT when they want to develop their concepts into a structural form; they could use the various software to produce plans and

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elevations to create construction drawings for the buildings they intend to design. The other nine (9) software are still use by some students, but at a minimal level. The ratio of those who are good to those who are professionals are of a significant share of 19:9 for those who are good and 4:1 for those who are professionals at the software.

SECTION E: CAD PRESENTATION USAGE TABLE ANALYSIS ON 3D VISUALIZATION PHASE

Of fourteen (14) software, it was noticed that REVIT and AUTOCAD are the most used by MSc students to convert their developed plans and elevations to 3D models that show real time effects on the building so they can better have a glimpse of what the design will need and how it will look when it built.

SECTION F: CAD PRESENTATION USAGE TABLE ANALYSIS ON RENDERING PHASE

MSc students rated their prowess in the use of eight (8) software in rendering 3D models. These are SKETCHUP, REVIT, 3D STUDIO MAX, ENSCAPE, LUMION, V-RAY, RHINO 3D and BLENDER. The MSc students made use of REVIT more (54). They also use LUMION and SKETCHUP to render their 3D models to realism. It is noticed that V-RAY has least users, perhaps because the interface and settings are a bit complex to master. This also goes for the other software like 3D STUDIO MAX, BLENDER, etc.

SECTION G: CAD PRESENTATION USAGE TABLE ANALYSIS ON POST PRODUCTION PHASE

Some MSc students add final touch ups to 3D walkthroughs or render shots with the seven (7) software found in this category. These are PHOTOSHOP, ADOBE PREMIERE PRO, BLENDER, ENSCAPE, LUMION, V-RAY and RHINO 3D. Some (18) of the MSc students prefer to use PHOTOSHOP to edit their rendered images. This could be as a result of the user interface and the ease of navigation within the software. Some (17) are professionals at using LUMION because, it is user friendly and easy to acquire, but most importantly, it generates hyperrealistic rendered images and 3D walkthrough animations within a short time depending on the student's hardware capability.

Other software like BLENDER, ADOBE PREMIERE PRO, etc., are also used by the students, but many of them don't use these software for various reasons like user interface, navigation, settings, etc.

SECTION H: CAD PRESENTATION USAGE TABLE ANALYSIS ON PHYSICAL MODELLING PHASE

From the five (5) software listed in table G above were identified as providing easy user interface for the creation of 3D models. Some of the MSc students have used a 3D printer before to generate their physical models. SKETCHUP, used 28.8% of the time, is the most common software to use to achieve physical printed models while, AUTOCAD, with usage at 27.1%, comes in 2nd being also known and used by students, and the third place goes to 3D STUDIO MAX (25.4%) which is another powerful software that can also produce accurate 3D printed models.

It was also noticed that most of the students don't make use of 3D printers. This may be due to cost as the printers are not as affordable as they appear. They may also not possess the skills to use the device. If a student includes the use of 3D printed physical models in their presentations, it would be time efficient.

V. DISCUSSION OF FINDINGS AND RECOMMENDATIONS

From the various analyses, it is clear that more men use CAD than the women which is bit worrying as those who have not started using CAD may find it tedious to cope with their final deadline submission. A high percentage of MSc students are youths in the 20-25 years (62.7%) range. The shows that they are young and can still learn so much when it comes to developing their skills with various CAD software.

The information from the questionnaire showed that MSc students who are single have more time and are more focused to practice their skills with various CAD software. They are not exposed to the worries from relationships or family affairs which are considered time-consuming and can, thus, put more focus on their studio design projects. Most MSc students make use of their computers most times when they are opportune, and those who do this are more likely to keep improving and adapting to various CAD skills and are able to troubleshoot and come up with solutions to problems they would face in those software.

Timing for the completion of a CAD design is dependent on skills, the availability of appropriate software/hardware and constant power. For the latter, the high percentage of 64.4% emanates from Bells University of Technology which has 25 students who are in MSc. This shows that, power supply is a key factor to consider; a student may have the best computer workstation, but it is not of any value when there is no power supply to the computer when in use. This was found in the MSc 1 and 2 students in the private universities who have constant power supply within their campus, which enables them to complete their projects in time for the presentation.

This research also shows that male MSc students are more skilled in the use of the some of the 23 software listed while the female students, 14 of which are in MSc 1 with 2 in MSc 2, use their computers less for their studio design projects. Findings show that there are some preferred software that the students use in their studio projects, and these are SKETCHUP, REVIT, AUTOCAD, 3D STUDIO MAX, LUMION, V-RAY, PHOTOSHOP, and COREL DRAW. Other software are used sometimes by the students, but rarely and only as the need arises.

Cost could also be a factor as to why the number of software used are less in number, this can take two forms - either those software are too expensive for them to afford or they don't have the required hardware to run such software.

One solution to the problems noticed from the survey is to start up a course in the various architectural departments in the universities for those in the MSc level, this course should specialize in organizing tutorial classes to address the 23 software, including others not mentioned in this study so that students can be well grounded in handling those software to achieve their designs.

It is recommended that universities or architecture departments or schools partner with the companies that own these software, enabling students to acquire them to achieve their studio designs at a reasonable cost. AUTODESK already has this partnership feature for REVIT, and it is being utilized well by the students. Such practice will enable students benefit from access to other software like LUMION which has an expensive license.

Furthermore, training exercises could be organized for the students to bring them up to speed. At the end of the training seminar, they will be tested in their knowledge of CAD usage and given designs to do using any CAD software of their choice, then they will be issued a certificate of professionalism in the use of those CAD software that were used, according to their skill, knowledge, project, accuracy and quick delivery time.

In so doing, Nigeria should be able to compete fairly in the world of architecture.

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